REMARKS

The present amendment makes editorial changes and corrects typographical errors in the specification, which includes the Abstract, in order to conform the specification to the requirements of United States Patent Practice. No new matter is added thereby.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned **"Versions with Markings to Show Change Made."**

In addition, the present amendment cancels original claims 1-13 in favor of new claims 14-26. Claims 14-26 have been presented solely because the revisions by crossing out underlining which would have been necessary in claims 1-13 in order to present those claims in accordance with preferred United States Patent Practice would have been too extensive, and thus would have been too burdensome. The present amendment is intended for clarification purposes only and not for substantial reasons related to patentability pursuant to 35 U.S.C. §§101, 102, 103 or 112. Indeed, the cancellation of claims 1-13 does not constitute an intent on the part of the Applicants to surrender any of the subject matter of claims 1-13.

Early consideration on the merits is respectfully requested.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

~~SPECIFICATION~~

TITLE OF THE INVENTION

ALTERNATING UPLINK/DOWNLINK TRANSITIONS IN CHANNEL ALLOCATION IN A TDD TRANSMISSION FRAME WITH A NUMBER OF SWITCHING TIMES

~~Description~~

~~Alternating uplink/downlink transitions in channel allocation in a TDD transmission frame with a number of switching times~~

BACKGROUND OF THE INVENTION

The present invention relates to a method for controlling uplink/downlink transitions in channel allocation in a transmission frame, particularly a TDD transmission frame ~~as claimed in the preamble of claim 1~~, and a communications system for carrying out the method.

In radio communications systems, information (for example, voice, image information or other data) are transmitted with the aid of electromagnetic waves via a radio interface between the transmitting and receiving radio station (base station or mobile station, respectively). The electromagnetic waves are radiated at carrier frequencies which are in the frequency band provided for the respective system. In the case of GSM (Global System for Mobile Communication), the carrier frequencies are in the range of 900, 1800 or 1900 MHz, respectively. For future mobile radio networks with CDMA or TD/CDMA transmission methods via the radio interface, for example the UMTS (Universal Mobile Telecommunications system) or other third-generation systems, frequencies in the frequency band of ~~approx.~~ approximately 2000 MHz are provided.

Frequency Division Multiple access (FDMA), Time Division Multiple Access (TDMA) or a method known as Code Division Multiple Access (CDMA) are used for distinguishing between the signal sources and, thus, for evaluating the signals. A particular instance of the time division multiple access is a TDD (Time

Division Duplex) transmission method in which the transmission takes place in a common frequency band separated in time both in the uplink, i.e. from the mobile station to the base station, and in the downlink, i.e. from the base station to the mobile station.

In the TDD system, uplink and downlink time slots are located within one transmission frame. Assuming that only one frequency band (one carrier frequency) is available to an operator, time slot clustering can be introduced in a channel assignment method in order to be able to guarantee the reusability of the channel (i.e., time slot) with a certain spacing. The channel allocation method has the task of distributing the available resources, on the one hand, to the cells (which occurs on a rather slow time axis) and, on the other hand, to allocate one (or more) resource(s) for a particular connection (service). The method proposed in the text which follows is classed as the former, in particular.

For two adjacent cells Z1 and Z2, shown in ~~figure~~ Figure 1, with base stations BS and mobile stations MS, particularly strong interferences are obtained from a mobile station MS which is close by in the adjacent cell, with synchronous alignment of the transmission frames of the adjacent stations or cells for a mobile station MS which receives signals from its associated base station BS. This case, which occurs quite frequently with a homogeneous distribution of the mobile stations, is critical especially at the cell boundaries.

According to ~~figure~~ Figure 2, interferences are obtained for the constellation where the transmit case TX of a mobile station MS overlaps the receive case RX of the other mobile station MS. A switching point SP in each case separates the transmit case TX and the receive case RX. For a frame-by-frame transmission, one frame fr ~~comprising~~ having a number of time slots ts, the duration of the occurrence of interferences depends on the displacement of the beginning of the frame and position of the switching point SP between the two cells Z1, Z2. Strong interferences cause losses in the spectral efficiency of the radio communications system.

In common TDD methods, therefore, there is frame synchronization and no variable switching time but a fixed switching time so that a fixed allocation exists

within the communication network (e.g., time slots 0-11 for downlink, 12-23 for uplink).

Frame synchronization alone, however, does not yet lead to optimum results if the requirements for the capacity utilization are different in adjacent cells. In particular, the case is unsolved in which relatively large data volumes are to be transmitted in the uplink in one cell but relatively large data volumes are to be transmitted in the downlink in adjacent cells.

From US 5,719,859, a TDMA radio communications system is known in which a single base station communicates with a multiplicity of mobile stations within its transmitting range. In this arrangement, individual channels of a transmission frame are variably allocated to the mobile stations in dependence on load. Furthermore, it is specified to include within a transmission frame its time slots for uplinks from the beginning of the transmission frame and to include its time slots for downlinks from its end to its beginning. Each time slot is only allocated for a single mobile station and only for a single transmit direction.

An extension of this communications system to a cellular communications system ~~comprising~~ having a multiplicity of adjacent cells is known from WO 98/29988 A1. In this document, it is proposed to group a multiplicity of radio cells and sectors within it in the manner of a cluster. In the arrangement, sectors of two different cells are, in each case, directly adjacent so that a cluster of two is formed. Furthermore, it is specified to subdivide the transmission frames into two subframes, one subframe being expressly used only for either uplinks or downlinks. Furthermore, it is specified to assign the two subframes to the different sectors. Accordingly, it is possible during one frame either only to receive or only to transmit in the sector of each cell independently of the other statements. For the next frame, in consequence, the transmit direction must be reversed for the entire transmission frame.

The resources are assigned in accordance with a similar basic principle as in US 5,719,859, but in this case only a distribution of packet data to these subframes is specified ~~but~~ and not an assignment of channels of a TDD system.

The present invention is ~~based on the object of~~, therefore, directed toward providing an improved method and an improved communications system, particularly a radio communications system, in which the switching points between uplink and downlink transmission times can be selected more variably in adjacent cells.

This object is achieved by the method having the features of claim 1 and the communications system having the features of claim 12. Advantageous further developments can be found in the subclaims.

SUMMARY OF THE INVENTION

In its basic concept, the TDD transmission method can also support asymmetric services in which the transmission capacity in the uplink does not need to be equal to that in the downlink. If this asymmetry is not wanted to the same extent in all radio cells, a critical interference scenario can arise. The considerations relating to the TDD transmission method had failed to recognize the relevant problems of the mutual interferences of a multiplicity of base stations and mobile stations operated within the same frequency band.

A method is proposed here which provides an optimum distribution of the time slots within the transmission frame ~~and particularly~~(particularly, the TDD transmission frame) and at the same time enables the following two criteria to be ~~realized~~ achieved at the same time:

1. Changing uplink/downlink conditions can be taken into consideration by a variable switching point between the uplink and downlink time slots within a cell almost independently of the switching points of the other cells.

2. A changing load distribution in the network can be made possible by extending the access time for a connection in one cell or, in other words, by allocating a different number of channels (time slots) per cell in reuse.

Due to the condition of aligned uplink or downlink direction in adjacent active cells or cell groups, the two criteria do not lead to the problem of ~~cochannel~~ co-channel interference in the form of mutual interference of two mobile stations in directly adjacent cells of different reused clusters, one of which is transmitting exactly on the channel (time slot) on which the other one is receiving at the same

time. The same applies to interference between base stations when both are transmitting or receiving on the same time slot.

Using the solution proposed here, the TDD mode can now ~~also~~ be implemented ~~by means of~~ via only one frequency.

The proposed combination of separate switching points per cell (see case a in the text which follows) and of the advantage of an unchanged link direction of the same time slots (see case b in the text which follows) makes it possible that the unwanted MS-MS interferences will not occur both in the case of a change in the uplink/downlink (UL/DL) ratio in the cell and in the case of a load change (different resource distribution over the cells in the cluster). To this end, this method uses a number of switching points (one per cell) with alternating UL/DL change of successive cell-related channel allocations within the transmission frame (see case c).

In clusters of three or four, only the switching points of up to three or four cells or groups of cells need to be correspondingly matched to one another in each case.

~~In the text which follows, exemplary embodiments are explained in greater detail with reference to the drawing, in which:~~

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows two cells with one base station and one mobile station each~~;~~.

Figure 2 shows the case of interference between two adjacent mobile stations, one of which is transmitting and the other one is receiving at the same time~~;~~.

Figure 3 shows a block diagram of a mobile radio system~~;~~.

Figure 4 shows a mobile radio system according to a first exemplary embodiment in a macro environment with a cluster of three and the associated transmission frames with a number of switching points~~;~~.

Figure 5 shows this mobile radio system and its transmission frame with a number of switching points and a different number of time slots per cell with interference~~,~~.

Figure 6 shows this mobile radio system and its transmission frame with a common switching point and a different number of group time slots per cell~~,~~.

Figure 7 shows this mobile radio system and its transmission frame with a different switching point in each case per transmission frame and a different number of time slots per cell in an interference situation~~,~~.

Figure 8 shows this mobile radio system and its transmission frame with a number of switching points with the same link direction of adjacent cells~~,~~.

Figure 9 shows this radio system and its transmission frame with a number of time-variable switching points with tolerable interference~~,~~.

Figure 10 shows this mobile radio system and its transmission frame with a number of time-variable switching points and a different number of time slots per cell with tolerable interference~~,~~.

Figure 11 shows, according to a further exemplary embodiment, a different scenario with microenvironment and a cluster of three with transmission frame~~,~~.

Figure 12 shows an exemplary scenario with microenvironment and a cluster of two with transmission frame~~,~~.

Figure 13 shows a mobile radio system with a medium time slot reuse distance of 4 ~~and~~.

Figure 14 shows a block diagram of a control device.

DETAILED DESCRIPTION OF THE INVENTION

As can be seen from ~~figure~~ Figure 3, an exemplary mobile radio communications system consists of a multiplicity of mobile switching centers MSC which are networked together or, respectively, establish access to a fixed network PSTN. Furthermore, these mobile switching centers MSC are connected to, in each case, at least one device RNM for allocating radio engineering resources. Each of these devices RNM, in turn, provides for a connection to at least one base station BS. The term base station in its widest interpretation can ~~also~~ be interpreted only as the site of, for example, a transmitting antenna. Such a base station BS can set up a

connection to other radio stations~~,~~; e.g., mobile stations MS or other mobile and stationary terminals via a radio interface. Each base station BS forms at least one radio cell Z. In the case of sectorization or with hierarchical cell structures, a number of radio cells Z are also supplied per base station BS~~,~~; e.g., for part-areas around the base station BS.

Figure 3 shows exemplary connections V1, V2, V3 for transmitting user information and signaling information between mobile stations MS1, MS2, MS3, MSn and a base station BS. An operation and maintenance center OMC implements control and maintenance functions for the mobile radio network or parts thereof, respectively. The functions of this structure can be transferred to other communications systems, particularly radio communications systems in which the method below can be used, and particularly for subscriber access networks with wireless subscriber loop.

Figure 4 and the subsequent figures show a mobile radio system with macroenvironment typical of the ideal, and the associated transmission frames from its cells Z. According to the ETSI simulation rules for macro and microenvironment in UMTS 30.03, macroenvironment ~~means that~~ refers to a high mast, which clearly protrudes over the roof edge of houses, ~~is~~ being used for transmitting and receiving. In this connection, N = 16 is assumed to be the number of time slots available in the transmission frame and, furthermore, a cluster of three cell division is provided which will be called cells R (dotted), G (shaded to the right) and B (shaded to the left) in the text which follows. Each cell also has a particular number of uplink and downlink time slots (e.g., $n_u(R)$ is assumed to be the number of uplink time slots per cell R).

In the representation, a first central cluster in the cell mapping is shown dotted, with shading to the left or shading to the right depending on group and with regard to the transmission allocation in the upper diagram for the purpose of illustration. Compared with other clusters surrounding this cluster, this central cluster is surrounded by a frame. Regarding the transmission allocation, the transmission parameter of the other adjacent clusters are shown in the lower diagram in each case. White circles represent the positions of the base stations BS

with sector antennas which, in each case, supply three surrounding cells Z (R, G, B) which are typically shown diagrammatically as hexagons for the purpose of simplification.

However, alternative arrangements are also possible such as, for example, the arrangement of, in each case, a separate base station with an omnidirectional antenna in the center of each individual cell.

The method proposed here is shown in individual stages ~~by means of~~ via the subsequent steps and figures for the purpose of clarity of explanation.

Case a: Figure 4 shows a clustering with a number of switching points; i.e., each cell both in the cluster and in reuse has its own UL/DL switching point. In this arrangement, the switching points can be different within ~~the~~ each ~~cells~~ cell ~~in each of~~ of a group of cells compared with the switching points of the other group members. The number of time slots per cell, however, is still fixed. All cells are allocated the same number of resources. The transmission frames of the adjacent cells of the three groups are suitably controlled synchronously in such a manner that all transmission frames simultaneously begin with time slot 1 for transmitting general information of the base stations to mobile stations in the corresponding cells in the downlink.

Using multiple switching points, i.e. a separate switching point per cell, ensures a situation of minimum interference with changing uplink/downlink relationships. If the switching point is shifted, MS/MS interference will arise between adjacent mobile stations but a minimum distance D is maintained between the mobile stations so that the interference situation is relatively noncritical. As an example, transmission in the fourth channel or time slot will be quoted where a cell of the central group transmits in the downlink but the adjacent cells of this group transmit in the uplink, with a minimum distance D. MS/MS interference between two mobile stations in the same cell groups and with the same transmission channel is thus permissible due to the minimum distance D.

If, however, given this channel allocation strategy, it is intended to take into account an inhomogeneous load distribution which leads to a change in the number of channels, i.e. shift the time slots of a cell with little traffic volume into a cell with

a large traffic volume within the cluster, this minimum distance is no longer given under certain conditions as shown in ~~figure~~ Figure 5. The critical MS/MS interferences will occur here since the number of time slots per cell changes within reuse in such a manner that the MS/MS ~~inteference~~ interference for time slots 7 and 8, i.e. for cells of different groups, exists to its full extent in this case since the minimum distance D is no longer given.

Case b:a channel allocation method according to ~~figure~~ Figure 6 which uses only one switching point, i.e. groups the time slots for uplink and downlink, is better suited with respect to a changing distribution of the time slots to the cells while at the same time ensuring minimum interference. Due to the joint switching of the transmit direction in all cells, there can be no MS/MS interferences. For example, there can be a different distribution of the time slots to the three sectors at each site within one transmit direction in ~~figure~~ Figure 6. It is now possible to violate the minimum reuse distance, e.g., in the downlink between cells of different direction~~,~~; i.e., a mobile station MS is simultaneously receiving data or signals from two adjacent base stations. For mobile stations close to their base station, this does not represent a problem because the level differences are adequate. The mobile stations located in the center between supplying and interfering base station so that they receive approximately the same signal levels can be allocated undisturbed~~,~~; i.e., in particular, different time slots in which these collisions cannot occur.

If, in contrast, the switching point changes, it is possible that, in addition to the lacking minimum distance D, the abovementioned MS/MS interference also occurs as shown in ~~figure~~ Figure 7. If the switching point in the reuse cluster changes due to another UL/DL ratio, they will be correspondingly extremely disturbing MS/MS interferences with only one switching point per transmission frame and grouped uplink/downlink time slots.

Case c: if the advantages of the two methods are combined, an allocation arrangement is obtained which has no problematic MS/MS interferences in the case of a change of the UL/DL ratio and changing traffic volumes. This optimized method provides for a number of variable switching points, on the one hand, but also a minimization of the situation that there is simultaneous transmission and

reception, respectively, (MS/MS interference) in the same channel (time slot) in directly adjacent cells. As shown in ~~figure~~ Figure 8, this can be achieved by the fact that the transmit direction does not change in the time slots at the boundary to the next cell in the cluster or preferably in the entire communication network of the environment (as at b). ~~i.e.~~ That is, if, for example, the last time slot belonging to cell G is in the uplink, the first time slot belonging to cell R ~~must~~ also must be in the uplink. There will then not be any UL/DL change at the cell boundaries within the transmission frame. This provides an alternating UL/GL allocation for cell B, DL/UL allocation for cell G and again UL/DL allocation for the next cell in the cluster. Figure 8 thus represents a hybrid method with alternating UL/DL changes for successive cells in the transmission frame.

If then the ratio of uplink/downlink time slots in a cell is changed as is shown in ~~figure~~ Figure 9, there will admittedly be MS/MS interferences but the minimum distance D is maintained~~,~~; i.e., the situation of having mutually interfering mobile stations in immediate vicinity is avoided. That is to say, in this hybrid method, alternating UL/DL changes are possible for successive cells in the transmission frame, the UL/DL switching point being shifted within the cell.

The second critical application is the allocation of a different number of resources in the different cells due to traffic volumes which differ locally. In this case, shown in ~~figure~~ Figure 10, the minimum distance is admittedly no longer given but MS/MS interference in which the same time slot is used for different transmit directions in the immediate vicinity is avoided, nevertheless. Thus, a hybrid method with alternating UL/DL changes for successive cells in the transmission frame is also possible in which the number of resources per cell is differently distributed in the reuse cluster.

The hybrid method thus provides for combining of the two cases a and b, that is to say a number of switching points (preferably, but not necessarily, only one per cell) with alternating UL/DL changes of successive cell-specific channel allocations within the transmission frame.

As a further exemplary embodiment, another scenario of a cluster of three in a microenvironment as Manhatten grid network with exemplary transmission frame

is shown in ~~figure~~ Figure 11. Microenvironment here ~~means that~~ refers to the transmitting and receiving antennas ~~are~~ being clearly arranged below the roof edges and ~~are~~ being used for supplying streets between blocks of houses. The white lines here represent the streets and the dotted boxes represent blocks of houses. The antennas, which are preferably arranged away from street intersections between two blocks of houses each are used, as a rule, not for supplying the blocks but the streets. The transmission arrangement corresponds to that of ~~figure~~ Figure 10 in this case.

Figure 12 represents a further exemplary Manhatten scenario but here with a cluster of two, and a corresponding transmission frame. The arrangement of base stations within the cells is as in the previous example.

According to a further exemplary embodiment, ~~figure~~ Figure 13 shows another exemplary cell arrangement with a typical instance of cells in a real network with medium reuse of four. In this arrangement, arbitrary cell forms with variable numbers of adjacent cells which, for example, can be supplied with time slots in a medium reuse of four (compare the four-color theorem) are instanced in accordance with the inhomogeneous propagation conditions of real radio environments~~, i.e.~~. That is, in this arrangement, it is assumed that, instead of three groups of cells to be matched to one another, four groups R, G, B, W of cells are formed, the switching points and switching directions, as shown in the transmission frame, can be matched to one another in accordance with the hybrid allocation method from case c.

The base station BS contains a transceiver device TX/RX shown in ~~figure~~ Figure 14, which digital/analog-converts the transmit signals to be radiated, translates them from the baseband into the frequency range of radiation and modulates and amplifies the transmit signals. A signal generating device SA has first assembled the transmit signals into radio blocks and allocated them to the corresponding frequency channel and time slot. A signal processing device DSP evaluates receive signals received via the transceiver device GX/RX and performs a channel estimation.

For the signal processing, the receive signals are converted into symbols having a discreet set of values; for example, digitized. A signal processing device DSP which contains as digital signal processor, for example, a JD processor for detecting the user information and the signaling information in accordance with the JD (Joint Detection) CDMA method, evaluates the data sections. The interaction of the components and the setting of the switching point SP is controlled by a control device SE of the base station BS. Associated data on the switching point SP and the actual situations of the link are temporarily stored in a memory device MEM.

The mobile station MS contains, correspondingly adapted, the modules explained for the base station BS and additionally an operating panel T. At the operating panel T, the subscriber can make inputs, among other things an input for activating the mobile station MS or for setting up a connection to the base station BS.

The control device SE evaluates signals sent in the downlink and received by the mobile station MS and signals sent from the mobile station to the base station and determines the requirement for data to be transmitted in the DL and in the UL. The channels to be used and the switching points are established in accordance with the requirement. These data are preferably transmitted to the communicating device. Furthermore, the channels and switching points to be allocated are matched to the base stations of the adjacent cells. In an exemplary control method, a coarse pregrouping of the resources is first carried out on a slow time axis for a cluster of three. The number of time slots remaining after the BCCH time slot is advantageously divided by three and assigned to the individual cell groups. This coarse grouping can also be different if there is a corresponding requirement.

After that, a repeated determination is made on a faster time axis, i.e. in short time intervals, for checking current requirements, what allocation requirements exist for a cell and its adjacent cells. The resources are then correspondingly allocated and required switching points established for these cells; i.e., the original resources of adjacent cells are allocated for a first cell and/or the time slot is shifted for the switching.

Alignment ~~by means of~~ via the adjacent base stations themselves would be associated with a very high and frequent exchange of data among them. A central control of the resources and channel allocations and switching points for a multiplicity of base stations by, for example, the devices RNM for allocating radio engineering resources or the mobile switching centers MSC to which the current load conditions and resource requirements are in each case transmitted by the base stations BS~~,~~ is, therefore, simpler.

In the extreme case, control ~~could~~ also could be handled by the mobile stations but is then disadvantageously expensive.

Precontrol of the switching points and signaling to the communicating stations can take place, for example, via the BCCH (Broadcast Control Channel) in the downlink.

Although the present invention has been described with reference to specific embodiments, those of skill in the art with recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

~~Abstract~~

~~Alternating uplink/downlink transitions in channel allocation in a TDD transmission frame having a number of switching points~~

ABSTRACT OF THE DISCLOSURE

~~The invention relates to a~~ A method for controlling uplink/downlink transitions in channel allocation in a transmission frame for information transmission in a communications system ~~comprising~~ having a multiplicity of cells, in which a switching point between uplink and downlink ~~(UL/DL)~~ transitions is controlled in alignment with the respective switching point of adjacent cells~~,~~ in such a manner that the same uplinks and downlinks are predetermined in directly adjacent cells.

A load-dependent control of the uplink and downlink within individual adjacent cells or groups of cells becomes possible ~~by means of~~ via a variable activation of possibly a number of switching points and/or resources of the individual cells which are switched to be active. The cells are preferably arranged for this purpose in a cluster of three or four arrangement, a number of time-variable switching points (one each per cell) being used with alternating uplink and downlink change of successive cell-related channel allocations within the transmission frame.

~~Figure 10~~